A Study of Skin Allergy Classification using Machine Learning

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Summary

This paper studies the performance of Machine Learning model in classification the presence of skin allergy during skin patch test. We introduced two Machine Learning algorithms which are Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) to operate this binary classification problem and compare their performance. The SVM achieve an accuracy of 70.2% without any excessive preprocessing on an balanced dataset and achieve 96.2% accuracy on an extremely imbalanced dataset. Although these Machine Learning algorithms had achieved middle accuracy, there are still some concerns in the application to skin patch test. This will be discussed in Conclusion section of this paper.

Ⅰ. Introduction

Skin patch test is a type of skin allergy test which the skin will be exposed to substances which is suspected to trigger an allergy. A patch contains up to 10 cells and each cell contains different suspected substance will be directly contacting to patient's skin by attaching it onto the patient. After 24 hours, the patch will be detached and the skin parts which contacted directly to the cell will be observed at every time interval. The observations will be interpreted by dermatologist either the allergy occur on the contacted skin or not. Mostly the patch reading process will be carrying out by the dermatologist on device such as computer. However, there will be a concern that the representation of the image, in term of colour saturation, dynamic range or pixel intensity, on the monitor may be varied based on the setting or the tuning of the monitor used. This may aggravate the misreading circumstance of the patch test and the patient may miss the golden time for the treatment. Therefore, we carried out a study about the implementation of Machine Learning into skin patch test to minimize the reading ambiguities. Support Vector Machine (SVM) [1] and Linear Discriminant Analysis (LDA) [2] are implemented in this study. SVM achieve 70.2% accuracy on a balanced dataset and 96.2% accuracy on an extremely unbalanced dataset. Both accuracies were calculated by the mean of K-Fold Cross Validation. While LDA only achieve 59.7% on balanced dataset but 96.2% accuracy on extremely unbalanced dataset.

Ⅱ. Methodology

Support Vector machine, SVM

Support Vector Machine, SVM [1] is a supervised learning algorithm applied in regression and widely in classification. The objective of SVM [1] is to find and optimize a hyperplane which classifies the data points in a D-dimensional space. The dimension of the hyperplane is depending upon the number of features or the dimension of features. The data points which are closer to the hyperplane are called support vector and they are used to maximize the margin ff hyperplane.

Linear Discriminant Analysis, LDA

Linear Discriminant Analysis, LDA [2] is a dimensionality reduction algorithm that is used for supervised classification task. It projects features in higher dimensional space into lower dimension space. The objective of LDA is to maximize the distance between inter-class means and minimize the intra-class variation.

The skin patch which attached to the patient will be removed after 24 hours and photo of skin contacted with the patch will be captured at a fixed time interval.

Figure 1 shows the perspective transformed patch image which consists of 15 cells.

Before the data are fed into the model, the cells in the patch are cropped and resize to 224 x 224. The dataset is grouped into 2 classes, which are "Positive" which the allergy reaction does occur and "Negative" which no allergy reaction is observed. Both class labels are encoded as "1" for positive and "0" for negative. Figure 2 illustrates the cropped cells from a patch.

After resizing, the cropped cells are normalized and flattened into 1-D vector. PCA [3] is applied when validation the complete dataset due to memory efficiency. The models are validated by using K-fold cross-validation method. The reason to apply K-fold cross-validation is because our dataset is extremely imbalanced. This method can help to provide a more reliable performance metrics of the models.

Figure 1. Aligned Patch

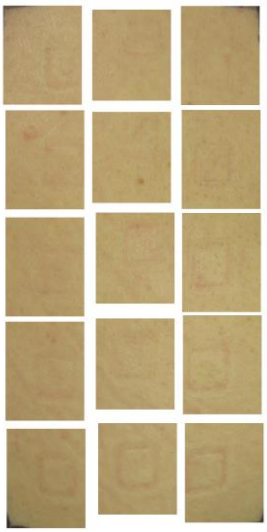

Figure 2. Cropped cells

Ⅲ. Experiment and Result

Our dataset was captured and collected from 33 patients. We collected 10 patch images with total 100 cell images from each patient therefore total 3300 cell images were collected. Among these 3300 cell images, images labelled "Positive" involve only 124 images which only accounts for 3.76% of total images count. From this dataset, we create a balanced dataset which consists of all 124 positive images and 124 randomly sampled negative images. Each SVM [1] and LDA [2] models are validated by K-fold Cross-Validation in K is set to 10 and will be repeated 3 times. Table 1 reports the mean accuracies about the validation results of the models.

Model	mAcc. (complete)	mAcc. (datapoints-balanced)
SVM [1]	96.2%	64.9%
SVM [1] (with linear kernel)	95.8%	78.7%
LDA [2]	96.2%	80.3%

*complete: all 3300 images are used
*datapoints-balanced: randomly sampled 124 negative images and all 124 positive images are used.

Table 1

When using complete dataset which is inter-class imbalanced, the models achieve mean accuracy above 95%. However, performance of all models dropped when validate using the relatively balanced dataset. The high accuracy achieved in full-sized dataset perhaps a result of overfitting to the negative class. Conversely, when using the random sampled balanced dataset, the accuracy achieved is rather a reasonable result.

IV. Conclusion

This paper yields the potential of machine learning model to classify the present of allergy reaction in skin patch test. However, there is still a big challenge about the data imbalance problem. In our study, the dataset collected consists only 3.76% positive images which is not an ideal dataset to train model. Either an inter-class balanced dataset or algorithm is needed to overcome this challenge. Considering the data is in image form, perhaps Convolutional Neural Network also a good choice in classifying the skin patch image. We will continue our study by focusing on data imbalanced problem and implementation of deep learning.

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